

The effectiveness of m-learning in knowledge retention of nurses' lifelong learning: quasi-experimental study

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The effectiveness of m-learning in knowledge retention of nurses' lifelong learning: quasi-experimental study

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Abstract

Background: The current Information and Communication Technologies, digital literacy, and ease of access to communication and information devices by nurses provide them with new ways and intention to access information for technical-scientific updating, ensuring the quality and safety of health care. M-learning offers a flexible and accessible alternative for continuing professional education, overcoming barriers such as time constraints and financial burden.

Objective: To evaluate the effectiveness of m-learning in nurses' knowledge retention of Chronic Obstructive Pulmonary Disease self-management, using a Massive Open Online Course with integrated virtual clinical simulation.

Methods: A quasi-experimental pre- and post-test study was conducted, with no control group, with 168 nurses from a Portuguese hospital. The intervention included an asynchronous online course with 13 modules. Knowledge retention was assessed by comparing the mean scores before and after the course.

Results: The results indicated a significant increase in knowledge retention. The participants' average score increased from 59.97% in the initial assessment to 84.05% in the final assessment ($p < .001$). Nurses with a master's degree exhibited a higher level of basic knowledge than those with a bachelor's degree. The course completion rate was 93.45%, reflecting significant engagement facilitated by gamification elements and the content's clinical relevance.

Conclusions: M-learning is useful in nurses' lifelong learning, offering flexibility and more effective support for clinical practice. Integrating virtual simulation and gamification boosted motivation and reduced drop-out rates, highlighting the potential of m-learning in lifelong learning in healthcare. This study confirms the effectiveness of m-learning in improving knowledge retention in nursing. This strategy is a valuable approach to lifelong learning, promoting quality and safety in delivering healthcare.

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Original Manuscript

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Background

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The results indicated a significant increase in knowledge retention. The participants' average score increased from 59.97% in the initial assessment to 84.05% in the final assessment ($p < .001$). Nurses with a master's degree exhibited a higher level of basic knowledge than those with a bachelor's degree. The course completion rate was 93.45%, reflecting significant engagement facilitated by gamification elements and the content's clinical relevance.

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M-learning is useful in nurses' lifelong learning, offering flexibility and more effective support for clinical practice. Integrating virtual simulation and gamification boosted motivation and reduced drop-out rates, highlighting the potential of m-learning in lifelong learning in healthcare.

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Keywords: m-learning; nursing; continuing education; knowledge retention; COPD; MOOC; clinical virtual simulation.

Introduction

Available Information and Communication Technologies (ICT), digital literacy, and easy access to communication and information devices provide nurses with new opportunities for technical and scientific updating. These advancements are directly linked to the safety and quality of care [1]. However, nowadays, there are still barriers to accessing lifelong learning [2], such as the need to balance family and professional life and the associated financial burden [3,4]. On the other hand, the decrease in human resources and their turnover and the increase in workload in health institutions are obstacles to nurses' continuing training [5,6].

The use of ICT based platforms by healthcare institutions as a strategy for providing lifelong learning to nurses enables large-scale access with no geographical and time limits [7-9].

The World Health Organisation (WHO) defines a digital health intervention as the specific use of digital technology to achieve health-related objectives. An example of these interventions is managing training and educational content and making it available to health professionals in digital format [10]. Digital education includes computer-based offline and online education, open and massive online courses, serious games and gamification, augmented reality environments, virtual reality, virtual simulations of clinical cases, psychomotor skills training and mobile learning (m-learning), among others [11].

E-learning, electronic learning or web-based learning often complement traditional teaching models, encompassing knowledge through digital technologies. These educational approaches promote access to training for health professionals [10,12].

The technological development has leveraged changes in education and fostered the use of mobile technologies in the acquisition of knowledge and its mobilisation for clinical practice [13]. Current distance education contexts demand the use of mobile devices in addition to traditional computers [14].

We have been witnessing the progressive introduction and incorporation of e-learning as a pedagogical strategy coupled with the growing access to portable distance communication

devices, such as smartphones and mobile internet networks. Within this new reality, m-learning has emerged as a new opportunity to promote nurses' access to digital education as a critical resource for lifelong learning. M-learning is the management and provision of education and training content in electronic format for healthcare professionals [10]. It allows users to access educational content via mobile devices, regardless of time and location [15]. Evidence shows that m-learning is at least as effective as traditional learning [11].

Massive Open Online Courses (MOOCs), made available by higher education institutions [16], certified and integrated into the in-service training programmes of health institutions, are emerging as important contributors to incorporating m-learning in the continuing training of health professionals. Moreover, MOOCs can contribute to developing nurses' skills, specifically in training for self-management of non-communicable chronic diseases such as Chronic Obstructive Pulmonary Disease (COPD).

Massive Open Online Courses

MOOCs are based on the definition of various concepts such as e-learning, mass communication, knowledge sharing and openness [17]. MOOCs comprise quality content and aim at a large target audience, overcoming many of the in-class barriers [9]. With over 20 years of existence, these courses stand out for their creative methodology for conveying information and implementing innovative pedagogy and tools [18]. The MOOC's primary goal in the health field is to improve the health status of the general population while promoting the safety and quality of the care provided [8].

In recent years, the number of MOOCs has grown exponentially, in line with the increase in the number of people with access to the internet [19,20]. In 2021, around 220 million people enrolled in online courses, representing twice the number of students enrolled in 2020 [21]. This reality explains the upward trend in using MOOCs, as they are easy to access and tend to be free [22]. The size of the global Massive Open Online Course (MOOC) market was 9.45 billion dollars in 2023, estimated to reach 39.72 billion dollars by 2032 [23].

MOOCs comprise several characteristics, such as openness, which means the possibility of enrolling and withdrawing from the course; autonomy, referring to the pace of learning and goal attainment; diversity, which allows adaption to different time zones; and interactivity, where the effects of learning picture the sharing between participants [8].

MOOCs have been perceived as an innovative method enabling useful and effective online learning compared to face-to-face training [8]. Its success relies on the number of trainees

that can be enrolled swiftly; its ability to respond to individual learning styles by using multiple tools for interaction between participants; its flexibility [2] and the guarantee of quality learning associated with cost savings in professional training.

In nursing education, the use of MOOCs has fostered the creation of broader learning opportunities for individuals and health institutions [24].

A MOOC must be designed considering the needs of the participants [25] and increase motivation and engagement. Continuous training that aims to respond to nurses' needs and is perceived as positive for the quality and safety of the care provided is more attractive and likely to better capture nurses' intention to attend and complete the course [26].

MOOCs used to develop professional competencies show higher enrolment and completion rates compared to more generic content [27,28].

The number of drop-outs in trainees from MOOCs before completion has been under analysis. In a study with nine million students, only 5 to 18% of participants completed the course [29]. Another study reported a MOOC completion rate of less than 10% [30]. More recently, MOOC drop-out rates have ranged from 10% [31] to 85% [32].

The advantages and personal and professional gains for individuals who attend MOOCs are irrefutable, considering the impact on learning and overall knowledge pertaining to the development of skills, attitudes, confidence and commitment [33].

Incorporating gamification features into MOOCs and using virtual patients for clinical decision training could help increase the involvement and motivation of participants to complete MOOCs [6,17,34]. MOOCs should integrate virtual patient simulators, recreating gamified environments, which are predictors of realism, fun and motivation for participants, and reduce the drop-out rate [4,35], thus increasing MOOC completion rates [36,37].

However, little is known about the effectiveness of using m-learning for nurses' lifelong learning. Therefore, this study sought to assess the effectiveness of an m-learning strategy on nurses' knowledge retention.

Methods

A quasi-experimental pre-and post-test study was conducted without a control group, using a non-probabilistic convenience sampling technique. All nurses from the Internal Medicine department of a central hospital in northern Portugal who voluntarily agreed to participate in the study were considered eligible. Thus, all 193 nurses from the Internal Medicine departments were eligible to participate.

The primary outcome of the study was the nurses' level of knowledge, analysed using a

continuous variable expressed as a % (0-100). The calculation of the average level of knowledge before and after attending the MOOC resulted from computing the relative weight of each module included in the intervention. Knowledge retention was calculated by testing the differences between the average % obtained before and after the intervention.

Intervention

The development of the MOOC was supported by the theme of self-management of COPD, considering the need expressed by the professionals within the study context and according to the Global Initiative for Chronic Obstructive Lung Disease – GOLD (2023, p.1). GOLD initiative reveals that 'Chronic Obstructive Pulmonary Disease is now one of the three leading causes of death in the world and 90% of these deaths occur in low- and middle-income countries...many people have suffered from this disease for years and die prematurely because of it or disease-associated complications. Globally, the burden of COPD is expected to increase in the coming decades due to continued exposure to COPD risk factors and an ageing population [38].

This study included a training programme available in MOOC format, called Self-Management of COPD (Ecare-COPD) [6]. This MOOC was made available on NAU, an e-learning platform, created and administered by the Scientific Computing Unit (FCCN) of the Foundation for Science and Technology (FCT). This model supports training and enables the design of training programmes in Portugal using the MOOC format.

This MOOC is organised into 13 modules integrating lessons on a topic. Each lesson includes a theoretical overview of the topic, one or more supporting videos (lasting about 5.06 minutes) and bibliographical references.

In addition, in one of the modules, each participant can practise clinical decision-making using four clinical scenarios supported by the Body Interact® virtual patient simulator [35,39-42].

The training programme was available online for approximately two months (20 April to 27 June 2023).

After completing all the modules, each participant was issued a certificate of completion, conditional to obtaining an overall assessment of 50% or more.

Data collection

Socio-demographic variables and variables characterising the professional category of the participants were used to characterise the sample.

The level of knowledge was assessed using a set of items, including 29 multiple-choice questions and 24 true or false statements, on the clinical area of COPD. The assessment items were determined by the experts who developed the contents of the training programme and validated by a group of experts in the field of the training programme.

Knowledge assessment was performed through an initial knowledge assessment of the participants after registering on the NAU platform. All participants were able to attend the training programme despite the initial assessment. Each participant was asked to complete a knowledge assessment at the end of each module.

Data analysis and processing

The statistical analysis was performed using IBM SPSS Amos v.29 and IBM SPSS Statistics v. 29 software. Descriptive statistics and inferential analysis were used to analyse the different variables under study. Student's t-test was used to test for differences between means. The results are reported according to APA standards, with Cohen's *d* effect magnitude (0.2 low; 0.5 mean and 0.8 high) and *p*-values set at $<.05$.

Ethical considerations

The study was approved by the Ethics Committee of the institution where the study was conducted (reference number 2021.010).

Results

This study included 168 nurses from the medicine department of a hospital in northern Portugal, representing 87% ($n=193$) of the total nursing staff in the department. The remaining 13% of potential participants were absent due to temporary work incapacity, extended health-related leave, and parental leave.

Of the participants 69.6% ($n=117$) were female, 11.3% ($n=19$) male, and 19% ($n=32$) preferred not to answer. These nurses were aged on average 32.96 years ($SD\pm 9.37$; $Med.=31$ and $Max.=59$), an average professional experience as a nurse of 10.12 years ($SD\pm 7.50$; $Med.=7$; $Min.=0$ and $Max.=37$), and an average experience of 6.43 years in the medicine department of this hospital in the north of Portugal ($SD\pm 6.22$; $Med.=4$; $Min.=0$ and $Max.=26$). Also, male nurses had the highest age $t(131)=-2.674$; $p=.004$; Cohen's $d=.67$ ($Men=37.94$; $Women=32.70$), longer professional experience $t(132)=-3.401$; $p<.001$; Cohen's $d=.86$ ($Men=15.17$; $Women=9.26$) and longer experience in the medical department $t(131)=-2.615$; $p<.005$; Cohen's $d=.66$ ($Men=10.17$; $Women=6.11$).

In this sample, 74.4% ($n=125$) of the nurses held a Bachelor's degree in nursing, 11.9%

(n=20) held a Master's degree, and 13.7% (n=23) opted not to disclose this information. Regarding professional categories, 66.1% (n=111) were general nurses, 19.6% (n=33) were specialist nurses, 1.2% (n=2) were nurse managers, and 13.1% (n=22) did not provide any information.

Regarding attendance at the training programme, data analysis revealed that out of 168 participants, 157 successfully achieved an evaluation score exceeding 50%, thereby qualifying for a certificate of participation and completion. Among these, 99.36% (n=156) were issued certificates, while 0.63% (n=1) had still not received their certificates at the time of data extraction. Additionally, 6.54% (n=11) of enrolled participants did not complete the training programme despite completing their registration.

The participants completed an initial knowledge assessment, achieving an average score of 59.97% (SD±19.37; Min.=0, Max.=97). The final knowledge retention assessment was calculated by determining the relative weight of each module. Participants scored on average 84.05% in the final assessment (SD±24.29; Min.=0, Max.=100).

Descriptive statistics for the evaluation of the 13 modules included in the training programme are described in Table 1.

Table 1 – Descriptive data for the assessment of the 12 modules of the formative programme

	N	Minimum	Maximum	Median	SD
Assessment of Module 1	158	0,33	1,00	92,01	17,81
Assessment of Module 2	158	0,00	1,00	80,70	27,49
Assessment of Module 3	158	0,33	1,00	98,11	8,58
Assessment of Module 4	158	0,40	1,00	88,28	14,33
Assessment of Module 5	158	0,40	1,00	92,48	14,04
Assessment of Module 6	158	0,00	1,00	83,33	24,97
Assessment of Module 7	158	0,25	1,00	88,85	16,60
Assessment of Module 8	158	0,00	1,00	58,97	49,35
Assessment of Module 9	158	0,00	1,00	67,95	46,82
Assessment of Module 10	158	0,00	1,00	83,44	37,29
Assessment of Module 11	158	0,20	1,00	91,28	16,09
Assessment of Module 12	158	0,00	1,00	87,90	32,72

Statistically significant differences in knowledge retention were found between the initial

assessment ($M=59.97$, $SD\pm19.37$) and the final assessment ($M=84.05$, $SD\pm24.29$); $t(167)=16.697$, $p<.001$, with a large effect size (Cohen's $d=1.28$).

An analysis of the relationships between sociodemographic and professional characteristics revealed a statistically significant difference in knowledge retention between the initial assessment scores of nurses with a master's degree ($M=69.15$) and those with a bachelor's degree ($M=62.52$); $t(143)=-2.037$, $p=.022$, Cohen's $d=.49$. These findings demonstrate that nurses with a master's degree have a higher baseline knowledge on this subject compared to those nurses with a bachelor's degree.

These study results confirm that the implemented pedagogical strategy significantly enhances knowledge retention among nurses within this specific context.

Discussion

This study included a sample of 168 nurses from the medicine department of a hospital in northern Portugal who achieved an average score of 59.97% on the initial knowledge assessment. Throughout the training programme, participants underwent final knowledge assessments at the end of each module, resulting in an overall average score of 84.05%. These findings demonstrate that the pedagogical strategy using ICT delivered through a MOOC and incorporating virtual clinical simulation significantly enhanced knowledge retention among nurses ($p<.001$, Cohen's $d=1.28$).

Numerous studies on educational programmes support these findings, highlighting their effectiveness in improving knowledge outcomes [43-46].

The positive impact of interventions involving simulation on knowledge acquisition is also well-documented, although primarily in studies with nursing students. These findings underscore the value of active learning strategies [47], which play a critical role in motivating trainees to acquire knowledge [48,49]. This evidence reinforces the rationale for integrating virtual clinical simulation and virtual patients into the MOOC's content.

This study also revealed that nurses holding a master's degree exhibited a higher level of knowledge in the initial assessment of this area compared to those with a bachelor's degree. These findings suggest that the second study cycle facilitates the consolidation of cognitive and instrumental skills and equips nurses with the ability to manage complex situations, such as empowering patients to self-manage chronic conditions like COPD. Consequently, a master's degree is expected to enable nurses to deliver specialized and targeted interventions that address the actual needs of the population, implement evidence-based complex interventions, and promote the quality and safety of care.

The training programme was conducted in a MOOC format and incorporated multimedia resources (e.g., videos) and brief summaries of the latest evidence on COPD. These features enhance the perceived usefulness of a MOOC [50], fostering greater engagement and commitment to the learning process [51] while increasing participants' intention to enrol in similar courses in the future [52].

These factors may help to explain the low drop-out rate observed in this training programme (6.55%), which is notably lower than those reported in previous studies [6,29-32,53].

As previously mentioned, the alignment of the MOOC with the participants' professional roles [27,28], specifically its focus on developing competencies to empower individuals with COPD to improve self-management of the disease, likely contributed to higher enrolment and completion rates.

Additionally, the flexibility provided to participants to complete the training programme [54] may have further supported the high completion rate by accommodating the professionals' needs to balance personal, family, and work responsibilities.

The use of simulation is increasingly significant in pre- and post-graduate programmes [55]. High-fidelity simulation enables recreating a situation or event in which a virtual patient represents and/or responds to physiological parameters, providing high realism and dynamism for those involved [56]. This helps to optimise engagement in the learning process. High-fidelity simulation, which can include simulation with virtual patients, improves learning satisfaction, confidence and self-efficacy among nursing students [57-59].

Virtual patient simulation has been used effectively to improve learning, specifically knowledge, self-confidence, practical skills, student satisfaction and critical thinking [35,60]. It contributes to transforming learning environments into more interactive and creative scenarios, facilitating participants' learning and achieving goals [61]. The integration of simulation with virtual patients, along with the gamification component of the training programme played a pivotal role in promoting adherence and achieving higher completion rates. Using simulation with virtual patients is an effective strategy for fostering active learning and stimulating intrinsic motivation to learn. This approach enabled the recreation of clinical decision-making environments and scenarios that participants were familiar with, allowing them to identify opportunities to enhance their decision-making skills when addressing daily challenges, in line with the findings from previous studies [4].

Limitations

The first limitation of this study is due to the small sample size, which was recruited from a specific healthcare context, namely, the medicine department of a single hospital; therefore, limiting the generalizability of the findings.

The second limitation pertains to the study's focus on a single dimension of nursing practice, specifically COPD self-management. Therefore, future research is recommended to explore the impact of implementing this pedagogical strategy in the context of continuing nursing education across other dimensions of nursing practice.

Additionally, future studies should focus on the longitudinal monitoring of the sample, particularly to assess knowledge retention on the subject under study.

Conclusion

The training programme demonstrated its effectiveness in improving knowledge retention; therefore, constituting a valuable alternative for optimizing nurses' lifelong learning.

The key features of the programme included the use of multimedia resources, brief summaries of the latest evidence on COPD, and its alignment with participants' professional roles, namely in empowering individuals with COPD to self-manage their condition, flexible schedules for attending the programme, and the possibility of issuing a certificate of attendance and completion. These features have contributed to the high completion rates of the programme (93.45%).

Furthermore, the integration of simulation with virtual patients, recreating scenarios and clinical contexts resonating with participants, likely enhanced adherence to and completion of the programme. This approach fostered motivation to learn and highly contributed to the development of nurses' decision-making skills.

Conflicts of Interest

None declared

Abbreviations

COPD – Chronic Obstructive Pulmonary Disease

ICT – Information and Communication Technologies

MOOC – Massive Open Online Course

MOOCs – Massive Open Online Courses

References

1. Ornellas TCF de, Monteiro MI. Lifelong learning entre profissionais de enfermagem: Desafios contemporâneos. *Rev Enferm Referência*. 2023;6(2):1-7. doi:10.12707/RVI22055.
2. Aung KT, Razak RA, Nor. Development of a Risk Communication in Massive Open Online Course (MOOC) Module for Nurses: A Process Description. *Educ Med J*. 2024;16(Supp.1):67-78. doi:10.21315/eimj2024.16.s1.8
3. Talan T. The Effect of Mobile Learning on Learning Performance: A Meta-Analysis Study. *Educ Sci Theory Pract*. 2020;20(1):79-103. doi:10.12738/jestp.2020.1.006.
4. Padilha JM, Rosa JF, Cunha DJ. Gamification in Healthcare Education: Demystifying a Trend. In: Bernardes O, Amorim V, Moreira A, eds. *Handbook of Research on the Influence and Effectiveness of Gamification in Education*. IGI Global; 2022:46-62. doi:10.4018/978-1-6684-4287-6.ch003.
5. Stevens CJ, Horrigan J, Heale R, Koren I. Northeastern Ontario nurses' perceptions of e-learning: An interpretive description. *Nurse Educ Today*. 2020; 92:104509. doi:10.1016/j.nedt.2020.104509.
6. Padilha JM, Machado PP, Ribeiro AL, Ribeiro R, Vieira F, Costa P. Easiness, usefulness and intention to use a MOOC in nursing. *Nurse Educ Today*. 2021;97:104705. doi:10.1016/j.nedt.2020.104705
7. Zhao Y, Wang A, Sun Y. Technological environment, virtual experience, and MOOC continuance: A stimulus–organism–response perspective. *Comput Educ*. 2020;144(C):14. doi:10.1016/j.compedu.2019.103721.
8. Longhini J, Rossetini G, Palese A. Massive open online courses for nurses' and healthcare professionals' continuous education: a scoping review. *Int Nurs Rev*. 2021;68(1):108-121. doi:10.1111/inr.12649.
9. Bettiol S, Psereckis R, MacIntyre K. A perspective of massive open online courses (MOOCs) and public health. *Front Public Health*. 2022;10. doi:10.3389/fpubh.2022.1058383.
10. World Health Organization. WHO guideline Recommendations on Digital Interventions for Health System Strengthening. WHO. 2019. Available at: <https://www.ncbi.nlm.nih.gov/books/NBK541902/>.
11. Car J, Carlstedt-Duke J, Tudor Car L, Posadzki P, Whiting P, Zary N, Atun R, Majeed A, Campbell J. Digital Education in Health Professions: The Need for Overarching Evidence

Synthesis. *J Med Internet Res*. 2019;21(2):e12913. doi:10.2196/12913.

12. Digital skills and competences and successful digital education and training: fit for the digital era. Consilium. Published 2023. Accessed February 7, 2025. <https://www.consilium.europa.eu/en/press/press-releases/2023/11/23/digital-skills-and-competences-and-successful-digital-education-and-training-fit-for-the-digital-era/>

13. Harbali SM, Koç Z. Change in Nursing Education: Mobile-Based Learning Approaches. *J Educ Res Nurs*. 2022;19(1):123-127. doi:10.5152/jern.2022.29053.

14. Şenyuva E. Reflections on Nursing Education of Technological Developments. *Florence Nightingale Hemsire Derg*. 2019;27(1):79-90. doi:10.26650/fnjn322556.

15. Picciano AG. Theories and frameworks for online education: Seeking an integrated model. In: *A Guide to Administering Distance Learning*. Brill; 2021:79-103. doi:10.1163/9789004471382_005.

16. Alharbi AH. Investigating the acceptance and use of massive open online courses (MOOCs) for health informatics education. *BMC Med Educ*. 2023;23(1). doi:10.1186/s12909-023-04648-9.

17. Aparicio M, Oliveira T, Bacao F, Painho M. Gamification: A key determinant of massive open online course (MOOC) success. *Inf Manag*. 2019;56(1):39-54. doi:10.1016/j.im.2018.06.003.

18. Rambe P, Moeti M. Disrupting and democratising higher education provision or entrenching academic elitism: towards a model of MOOCs adoption at African universities. *Educ Technol Res Dev*. 2017;65(3):631-651. doi:10.1007/s11423-016-9500-3.

19. Zhu M, Sari AR, Lee MM. A comprehensive systematic review of MOOC research: Research techniques, topics, and trends from 2009 to 2019. *Educ Technol Res Dev*. 2020;68(4):1685-1710. doi:10.1007/s11423-020-09798-x.

20. Liu C, Zou D, Chen X, Xie H, Chan WH. A bibliometric review on latent topics and trends of the empirical MOOC literature (2008–2019). *Asia Pac Educ Rev*. 2021;22(3):515-534. doi:10.1007/s12564-021-09692-y.

21. Shah D. Class Central's Best Online Courses of the Year (2022 Edition) — Class Central. The Report by Class Central. Published December 27, 2021. Accessed February 7, 2025. <https://www.classcentral.com/report/best-free-online-courses-2022>

22. Almeida BL, Christovam BP, Correia DM. El uso de blog como estrategia de formación continua en enfermería: una revisión integradora de la literatura. *Enferm Glob*. 2017;17(1):500-528. doi:10.6018/eglobal.17.1.277841

23. MOOCs Market Share, Trend, Growth, Forecast Research, 2032. Business Research Insights. 2024. Available at: <https://www.businessresearchinsights.com/market-reports/moocs-market-112194>.
24. Dağcı M. Massive Open Online Courses in Nursing: A Retrospective Descriptive Study. Sağlık Bilimleri ve Klinik Araştırmaları Dergisi. 2024;3(3):194-203. doi:10.5281/zenodo.14576715.
25. Zubala A, Lyszkiewicz K, Lee E, Underwood LL, Renfrew MJ, Gray NM. Large-scale online education programmes and their potential to effect change in behaviour and practice of health and social care professionals: a rapid systematic review. Interact Learn Environ. 2018;27(5-6):797-812. doi:10.1080/10494820.2018.1465438.
26. Cunha DJ, Machado PP, Padilha JM. Aceitação pelos Enfermeiros da utilização de um Massive Open Online Course em contexto de formação contínua. Rev Port Enferm Reabil. 2024;7(1):e395. doi:10.33194/rper.2024.395.
27. Weinhardt JM, Sitzmann T. Revolutionizing training and education? Three questions regarding massive open online courses (MOOCs). Hum Resour Manage Rev. 2019;29(2):218-225. doi:10.1016/j.hrmr.2018.06.004.
28. Kizilcec RF, Kambhampaty A. Identifying course characteristics associated with sociodemographic variation in enrollments across 159 online courses from 20 institutions. PLoS One. 2020;15(10). doi:10.1371/journal.pone.0239766.
29. Korn M, Levitz J. Online Courses Look for a Business Model. The Wall Street Journal. Available at: <https://www.wsj.com/articles/SB10001424127887324339204578173421673664106>.
30. Breslow L, Pritchard DE, DeBoer J, Stump GS, Ho AD, Seaton DT. Studying Learning in the Worldwide Classroom Research into edX's First MOOC. Res Pract Assess. 2013;8:13-25. Available at: <https://www.learntechlib.org/p/157941/>
31. Magaña-Valladares L, Rosas-Magallanes C, Montoya-Rodríguez A, Calvillo-Jacobo G, Alpuche-Arande CM, García-Saisó S. A MOOC as an immediate strategy to train health personnel in the cholera outbreak in Mexico. BMC Med Educ. 2018;18(1):111. doi:10.1186/s12909-018-1215-1.
32. Wang W, Guo L, He L, Wu YJ. Effects of social-interactive engagement on the dropout ratio in online learning: insights from MOOC. Behav Inf Technol. 2019;38(6):621-636. doi:10.1080/0144929X.2018.1549595.
33. Blum ER, Stenfors T, Palmgren PJ. Benefits of Massive Open Online Course

Participation: Deductive Thematic Analysis. *J Med Internet Res.* 2020;22(7). doi:10.2196/17318.

34. Gentry S, L'Estrade Ehrstrom B, Gauthier A, Alvarez J, Wortley D, van Rijswijk J, Car J, Lilienthal A, Tudor Car L, Nikolaou CK, et al. Serious Gaming and Gamification interventions for health professional education. *Cochrane Database Syst Rev.* 2018;(6). doi:10.1002/14651858.CD012209.pub2.

35. Padilha JM, Costa P, Sousa P, Ferreira A. Clinical virtual simulation: predictors of user acceptance in nursing education. *BMC Med Educ.* 2024;24(1):299. doi:10.1186/s12909-024-05154-2.

36. Buckley P, Doyle E. Gamification and student motivation. *Interact Learn Environ.* 2014;24(6):1162-1175. doi:10.1080/10494820.2014.964263.

37. Khalil M, Wong J, Koning B, Ebner M, Paas F. Gamification in MOOCs: A review of the state of the art. 2018 IEEE Global Engineering Education Conference (EDUCON). 2018:1629-1638. doi:10.1109/EDUCON.2018.8363430.

38. Global Initiative for Chronic Obstructive Lung Disease. Report: GOLD Executive Summary. *Eur Respir Soc.* 2023;(4)(61). doi:10.1183/13993003.00239-2023.

39. Padilha JM, Sousa PA, Pereira FM. Análise do uso de suportes tecnológicos e conteúdos informacionais pelos pacientes com doença pulmonar obstrutiva crônica. *Acta Paul Enferm.* 2012;25(SPE1):60-66. doi:10.1590/S0103-21002012000800010

40. Padilha JM, Machado PP, Ribeiro AL, Ramos JL. Clinical Virtual Simulation in Nursing Education. *Clin Simul Nurs.* 2018;15:13-18. doi:10.1016/j.ecns.2017.09.005

41. Padilha JM, Machado PP, Ribeiro A, Ramos J, Costa P. Clinical Virtual Simulation in Nursing Education: Randomized Controlled Trial. *J Med Internet Res.* 2019;21(3):e11529. doi:10.2196/11529.

42. Padilha JM, Ribeiro A, Rosa J, Marques D, Machado PP. Clinical Virtual Simulation as Lifelong Learning Strategy—Nurse's Verdict. *Clin Simul Nurs.* 2020;47:1-5. doi:10.1016/j.ecns.2020.06.012

43. Keleekai NL, Schuster CA, Murray CL, King MA, Stahl BR, Labrozzi LJ, Gallucci S, LeClair MW, Glover KR. Improving Nurses' Peripheral Intravenous Catheter Insertion Knowledge, Confidence, and Skills Using a Simulation-Based Blended Learning Program: A Randomized Trial. *Simul Healthc.* 2016;11(6):376-384. doi:10.1097/SIH.0000000000000186.

44. Rutherford-Hemming T, Kelsey NC, Grenig DL, Feliciano M, Simko L, Henrich CM.

- Multisite Single-Blinded Randomized Control Study of Transfer and Retention of Knowledge and Skill Between Nurses Using Simulation and Online Self-Study Module. *Simul Healthc*. 2016;11(4):264-270. doi:10.1097/SIH.0000000000000168.
45. Eglseer D. Development and evaluation of a Massive Open Online Course (MOOC) for healthcare professionals on malnutrition in older adults. *Nurse Educ Today*. 2023;123:105741. doi:10.1016/j.nedt.2023.105741.
46. Khalil AI, Hantira NY, Alnajjar HA. The Effect of Simulation Training on Enhancing Nursing Students' Perceptions to Incorporate Patients' Families Into Treatment Plans: A Randomized Experimental Study. *Cureus*. 2023;15(8):e44152. doi:10.7759/cureus.44152.
47. Chan H, Chang H, Huang T. Virtual reality teaching in chemotherapy administration: Randomised controlled trial. *J Clin Nurs*. 2021;30(13-14):1874-1883. doi:10.1111/jocn.15701.
48. Torralba KD, Doo L. Active Learning Strategies to Improve Progression from Knowledge to Action. *Rheum Dis Clin North Am*. 2020;46(1):1-19. doi:10.1016/j.rdc.2019.09.001.
49. Jiang J-L, Fu S-Y, Ma Y-C, Wang J-H, Koo M. Comparative impact of active participation and observation in simulation-based emergency care education on knowledge, learning effectiveness, and satisfaction among undergraduate nursing students. *Teach Learn Nurs*. 2024. doi:10.1016/j.teln.2024.04.003.
50. Chan MM, Barchino R, Medina-Merodio JA, de la Roca M, Sagastume F. MOOCs, an innovative alternative to teach first aid and emergency treatment: A practical study. *Nurse Educ Today*. 2019;79:92-97. doi:10.1016/j.nedt.2019.05.008.
51. Lim WC, Haslam RL, Ashton LM, Fenton S, Collins CE. Motivations of learners enrolled on a Massive Open Online Course – 'The Science of Weight Loss: Dispelling diet myths'. *Health Educ J*. 2024;83(2):150-160. doi:10.1177/00178969231225060.
52. Molinillo S, Aguilar-Illescas R, Anaya-Sánchez R, Vallespín-Arán M. Exploring the impacts of interactions, social presence and emotional engagement on active collaborative learning in a social web-based environment. *Comput Educ*. 2018;123:41-52. doi:10.1016/j.compedu.2018.04.012.
53. Aydin CH. MOOCs as change agents. *OpenupEd Trend Rep*. 2018;201(8):18-21. Available at: https://www.openuped.eu/images/Publications/The_2018_OpenupEd_trend_report_on_MOOCs.pdf.
54. Jia M, Gong D, Luo J, Zhao J, Zheng J, Li K. Who can benefit more from massive open

- online courses? A prospective cohort study. *Nurse Educ Today*. 2019;76:96-102. doi:10.1016/j.nedt.2019.02.004.
55. Shorey S, Ng ED. The use of virtual reality simulation among nursing students and registered nurses: A systematic review. *Nurse Educ Today*. 2021;98:104662. doi:10.1016/j.nedt.2020.104662.
56. Hanshaw SL, Dickerson SS. High fidelity simulation evaluation studies in nursing education: A review of the literature. *Nurse Educ Pract*. 2020;46:102818. doi:10.1016/j.nepr.2020.102818.
57. Üzen Cura Ş, Kocatepe V, Yıldırım D, Küçükakgün H, Atay S, Ünver V. Examining Knowledge, Skill, Stress, Satisfaction, and Self-Confidence Levels of Nursing Students in Three Different Simulation Modalities. *Asian Nurs Res*. 2020;14(3):158-164. doi:10.1016/j.anr.2020.07.001.
58. Karataş Ç, Tüzer H. The Effect of Simulation-based Training on the Self-confidence and Self-satisfaction of Nursing Students Dealing with Patients under Isolation. *Bezmialem Sci*. 2020;8:227-232. doi:10.14235/bas.galenos.2019.3416.
59. Alsaraireh A, Madhavanprabhakaran G, Raghavan D, Arulappan J, Khalaf A. Effect of a high-fidelity simulation-based teaching-learning experience (SBTLE) on maternal health nursing students' knowledge of postpartum hemorrhage, confidence, and satisfaction. *Teach Learn Nurs*. 2023;19(1). doi:10.1016/j.teln.2023.10.009.
60. Foronda CL, Fernandez-Burgos M, Nadeau C, Kelley CN, Henry MN. Virtual Simulation in Nursing Education: A Systematic Review Spanning 1996 to 2018. *Simul Healthc*. 2020;15(1):46-54. doi:10.1097/SIH.0000000000000411.
61. Bernacki ML, Greene JA, Crompton H. Mobile technology, learning, and achievement: Advances in understanding and measuring the role of mobile technology in education. *Contemp Educ Psychol*. 2020;60:101827. doi:10.1016/j.cedpsych.2019.101827.